Symptomatic Decision Support System for Neurological Disorders

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Abstract

Symptomatic Decision Support System for Neurological Disorders is a web-based decision support system for diagnosis of neurologic disorders. This system uses Web based decision support system by encoding rules of the neurology domain and also by developing a framework to learn from the cases of the patients. This knowledge encoding is essentially the implementation of two artificial reasoning techniques called Case-Based Reasoning and Rule-Based Reasoning. The system will collect rules of the neurology domain expert and also the case history of the patients. The system will use the rules and cases to achieve the objective of assisting the decision-making process for the domain experts. Decision Support System will give the patient a symptomatic diagnostic conclusion. The system will provide case study of patients and also will display results in form of graphs.

Keywords: decision support system, neurological disorders, neurology

1. Introduction

The scientific name ***homo-sapiens*** *(Latin: "wise man")* is because of our mental capacities which are so important to our everyday lives. The field of artificial intelligence (AI) attempts to understand these capacities, better known as *intelligent entities*. AI, being a broad topic, combines Computer Science, Physiology and Philosophy. One of the large-scale applications of the field of AI is the development of *decision support system*. A decision support system is a knowledge-based computer program containing knowledge of human decision in a particular domain. In this research work, we intend to develop a hybrid decision system which integrates rule-based reasoning and case-based reasoning techniques (Adhikari et. al.; 2015).

A rule-based system is used when the problem area is narrow and also for well-understood domain theory. To overcome these limitations, the case-based reasoning technique is also integrated. This solves new problems based also on the solutions of similar past problems rather than merely using rules. This system is extensively used in the various fields of medicine, especially for medical diagnosis purpose. Some of these systems are already implemented to help in the diagnostics process related to blood infections, heart problems and kidney disorders. We intend to implement this system in the domain of *neurology* (Adhikari et. al.; 2015).

Neurology is a medical specialty dealing with disorders of the nervous system. Specifically, it deals with the diagnosis and treatment of all categories of disease involving the central, peripheral, and autonomic nervous systems, including their coverings, blood vessels, and all effectors tissue, such as muscle. Physicians who specialize in neurology are called neurologists, and are trained to investigate or diagnose and treat neurological disorders (Adhikari et. al.; 2015).

Computer aided tools are extensively used in the medical field these days. These tools possess a property of quick and accurate result, but require long learning processes and can be supported with decision support systems, which are not readily available in small hospitals and rural areas. The use of decision support system can fulfill requirements of fast decision making for neurologists. Hence, the purpose is to develop a Symptomatic Decision Support System as a flexible diagnostic support system (Logeswaran et.al.; 2015).

In the medical domain, the knowledge of experts does not only consist of rules, but a mixture of textbook knowledge and experience. The latter consists of cases, typical and exceptional ones, and the reasoning of physicians takes them into account. In medical knowledge based systems there are two sorts of knowledge, objective knowledge, which can be found in textbooks, and subjective knowledge, which is limited in space and time and which changes frequently (Schmidt, Gierl; 2012).

Symptomatic Decision Support System for Neurological Disorders is a web-based decision support system for the diagnosis of neurologic disorders. This system uses Web based decision support system by encoding rules in the neurology domain. This system essentially has implementation of two artificial reasoning techniques called ***CBR (Case-based reasoning and RBR (Rule-based reasoning).*** The system will collect rules of the neurology domain expert and cases of the patients. It will provide the patient with a diagnosis, and will provide them with the case study of related patients, which will be displayed in graphical form.

1.1. Artificial Intelligence

The tools of artificial intelligence (AI) can be divided into two broad types: ***Knowledge-based Systems (KBSs)*** and ***Computational Intelligence (CI)***. KBSs use explicit representations of knowledge in the form of words and symbols. This explicit representation makes the knowledge more easily read and understood by a human than the numerically derived implicit models in computational intelligence (Josefiok et. al., 2015).

1.2. Neurology Domain

Neurological disorders are disorders that can affect the central nervous system (brain and spinal cord), the peripheral nervous system, or the autonomic nervous system (Adhikari et. al.; 2015).

The following are the disorders which are considered for the research work:

- Parkinson
- Epilepsy
- Stroke

2. Knowledge-based Systems

Knowledge-based System is an artificial intelligence technique used to store complex information regarding a problem. The component of an expert system that contains the system knowledge organized in a collection of facts about the system domain. There are two reasoning methodologies which are followed for extracting data stored, they are:

- Rule Based reasoning
- Case-based reasoning

2.1. Rule-Based Reasoning

Rule-based systems have been around for quite some time now without breaking into mainstream computing. These systems represent the rules in the form of simple if–then blocks and the collections of facts and are controlled by an inference engine. In this research work, a rule is represented in form of decision chart (Berk, 1985).

The idea of rule-based systems is to represent a domain expert's knowledge in a form called rules. In a typical rule-based expert system, a rule consists of several premises and a conclusion. If all the premises are true, then the conclusion is considered true. The components of a rule-based expert system include the knowledge-base, inference-engine, knowledge acquisition component, and explanation system as illustrated in below Fig No. 1.

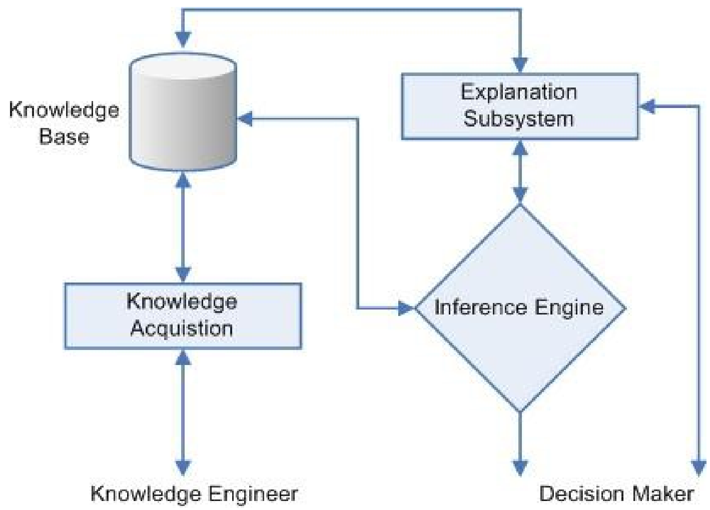

Figure 1. Rule Based System Cycle

Knowledge-base: a declarative representation of the expertise, often in IF THEN rules.
Inference engine: the code at the core of the system, which derives recommendations from the knowledge base and problem-specific data in working storage.
Knowledge acquisition: new rules can be added to the knowledge-base by using the knowledge acquisition sub-system.
Explanation sub-system: is its ability to explain its advice or recommendations, and even to justify why a certain action was recommended.

Knowledge-base is represented in a computer in the form of rules, consisting of a IF and THEN part. IF part lists a set of conditions in some logical combinations. If the IF part of the rule is satisfied, the THEN part can be concluded (Bilgi, Kulkarni; 2008). An Inference engine tries to derive answers from the knowledge base. It is the brain of the expert system which provides a methodology for reasoning about the information in the knowledge-base, and for formulating conclusion (Bilgi, Kulkarni; 2008).

Two people are involved in this system:

- **Knowledge Engineer:** A knowledge engineer is a computer scientist who knows how to design and implement programs that incorporates AI techniques.
- **Domain Expert:** A domain expert is an individual who has significant expertise in the domain.

2.2. Inference in rule-based systems

Two control strategies: Forward Chaining and Backward Chaining (Leake, 1996).
Example of inference engine:

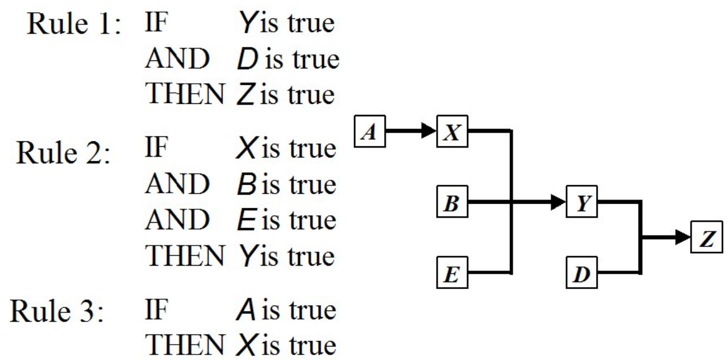

Figure 2. Rule diagram

2.3. Forward chaining

Forward chaining works from the facts toward a conclusion, sometimes called the ***data-driven approach.*** To chain forward, match data in working memory against 'conditions' of rules in the rule-base. When one of them fires, this is liable to produce more data, so the cycle continues (Schmidt, Gierl; 2012).

Process of moving from the "if" patterns to the "then "patterns and whenever an "if" pattern is observed to match an assertion: the ***antecedent*** is satisfied whenever the entire "if" patterns of a rule are satisfied ---> the rule is triggered; a triggered rule establishes a new assertion ---> it is fired.

Forward chaining is the data-driven reasoning. The reasoning starts from the known data and proceeds forward with that data. Each time, only the topmost rule is executed. When fired, the rule adds a new fact in the database. Any rule can be executed only once. The match-fire cycle stops when no further rules can be fired.

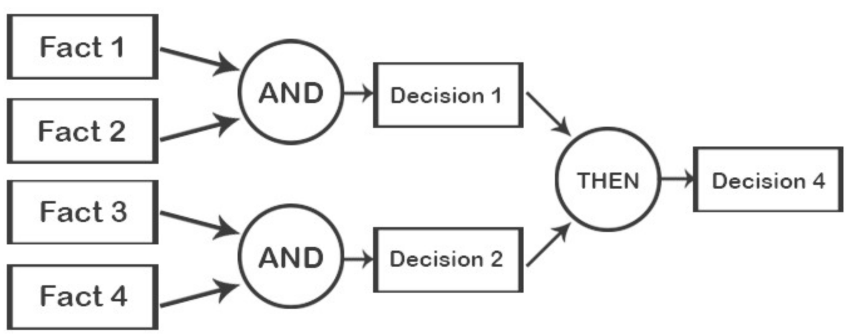

Figure 3. Forward chaining cycle

- Forward chaining is a technique for gathering information and then inferring from it whatever can be inferred.
- However, in forward chaining, many rules may be executed that have nothing to do with the established goal.
- Therefore, if our goal is to infer only one particular fact, the forward chaining inference technique would not be efficient.

2.4. Backward chaining

Backward chaining is the ***goal-driven reasoning***. In backward chaining, an expert system has the goal (a hypothetical solution) and the inference engine attempts to find the evidence to prove it. First, the knowledge-base is searched to find rules that might have the desired solution. Such rules must have the goal in their THEN (action) parts. If such a rule is found and its IF (condition) part matches data in the database, then the rule is fired and the goal is proved. However, this is rarely the case (Schmidt, Gierl; 2012, Leake; 1996).

Thus the inference engine puts aside the rule it is working with (the rule is said to stack) and sets up a new goal, a sub goal, to prove the IF part of this rule. Then the knowledge base is searched again for rules that can prove the sub goal. The inference engine repeats the process of stacking the rules until no rules are found in the knowledge base to prove the current sub goal.

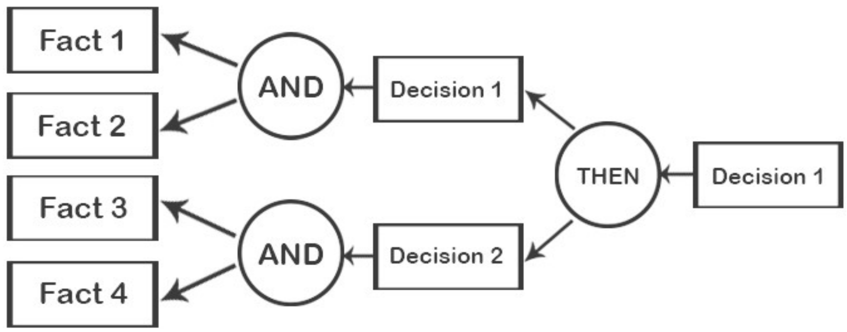

Figure 4. Backward chaining cycle

Backward chaining works the other way around:

- Keeps a list of yet unsatisfied atoms Q starting with the query atom.
- Tries to find rules which head match atoms in Q (after unification) and replaces the atom from Q by the atoms of the body of the matching rule.
- Proceed recursively until no more atoms have to be satisfied.
- Backward chaining keeps track of the substitution needed during the proof.

2.5. Case-Based Reasoning

Case-based Reasoning (CBR) has become a successful technique for knowledge-based systems in many domains, while in medical domains some more problems arise to use this method. We are going to discuss the appropriateness of CBR for medical knowledge-based systems, point out problems, limitations and possibilities how they can be partly overcome (Schmidt, Gierl; 2012).

Case-based Reasoning means to use previous experience in form of cases to understand and solve new problems. A case-based reasoner remembers former cases similar to the current problem and attempts to modify their solutions to fit the current case (Fig No.5 shows the Case-based Reasoning cycle (Robert & Chi, 1991). The underlying idea is the assumption that similar problems have similar solutions. Though this assumption is not always true, it holds for many practical domains.

CBR consists of two main tasks (Robert & Chi, 1991; Spyropoulos, Papagounos, 1995): The first is the retrieval, which is the search for or the calculation of most similar cases. If the case base is rather small, a sequential calculation is possible, otherwise faster non-sequential indexing (Spyropoulos, Papagounos, 1995; Spyropoulos, Parvantonis, 1996a) or classification algorithms (e.g. ID3 (Spyropoulos et. al., 1996b) or Nearest Neighbor match (Spyropoulos & Papagounos, 1997)) should be applied. For this task much research has been undertaken in the recent years and actually it has become correspondingly easy to find sophisticated CBR retrieval algorithms adequate for nearly every sort of application problem.

The second task, the adaptation (reuse and revision) means a modification of solutions of former similar cases to fit for a current one. If there are no important differences between a current and a similar case, a simple solution transfer is sufficient. Sometimes only few substitutions are required, but sometimes the adaptation is a very complicated process. So far, no general adaptation methods or algorithms have been developed; the adaptation is still absolutely domain dependent (Schmidt, Gierl; 2012).

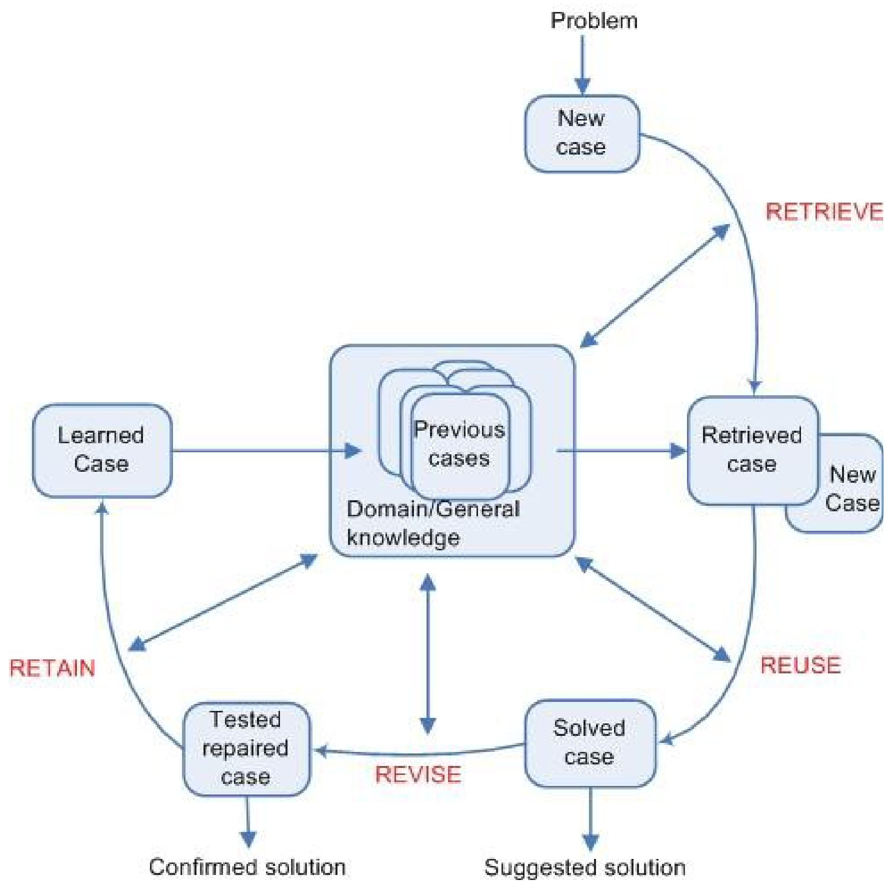

Figure 5. Case-Based Reasoning Cycle

The problem of updating the changeable subjective knowledge can partly be solved by incrementally incorporating new up-to-date cases. Both sorts of knowledge can clearly separate: Objective textbook knowledge can be represented in forms of rules or functions, while subjective knowledge is contained in cases. So, the arguments for case-oriented methods are as follows:

- Reasoning with cases corresponds with the decision-making process of physicians.
- Incorporating new cases means automatically updating parts of the changeable knowledge.
- Objective and subjective knowledge can be clearly separated.
- As cases are routinely stored, integration into clinic communication systems is easy.

3. Literature Survey

The proposed system Symptomatic Decision Support System is a system developed mainly to help medical practitioners to detect neurological disorders at an early stage. This is performed by using simple Query and Answer Session. The system will query for the symptoms and, on the basis of algorithm, will apply inference procedure on answers of queries, the output resulting as a possible disease diagnosis with accuracy. The proposed system is able to diagnose neurological disorders like Epilepsy, Stroke disease, Parkinson's disease.

A literature survey of related papers was conducted and following are some of papers which are reviewed.

Badri Adhikari, Md. Hasan Ansari, Priti Shrestha and Susma Pant propose a ***'Neurology Diagnosis System'*** which is a ***Web-based expert system***. The system will use the rules and cases to achieve the objective of assisting the decision-making process of the domain experts. The architectural goal is to improve rule-based reasoning by augmenting it with case-based reasoning. The idea is to fine-tune the performance of the rules. Another advantage is that if the case-based reasoning misses a similar case, the architecture will, at least, have a reasonable default answer generated by the rule-based system (Adhikari et. al.; 2015).

Rainer Schmidt, Lothar Gierl has attempted to apply the complete CBR cycle in rather exceptional way. Some systems have recently been developed, which, on the one hand, use only parts of the CBR method, mainly the retrieval, and, on the other hand, enrich the method by a generalization step to fill the knowledge gap between the specificity of single cases and general rules (Schmidt, Gierl; 2012).

Atul Krishan Sharma, Stuti Gupta have proposed a system which is a rule based expert system allowing non-experts to detect the nervous system disorders at an early stage. The system consists of a knowledge-base with some facts, and of developing a framework to learn from the cases of the patients. This knowledge encoding basis of facts is updated with the medical practitioner filling in the symptoms as input. The system by applying inference procedures will return the output as results (Bilgi, Kulkarni; 2008).

Dr. D.K. Sreekantha, T.M. Girish and Dr. R.V. Kulkarni have developed an innovative IT based solution system to help doctors in rural areas to gain expertise in neuro-science and treat patients like expert neurologist. The present work comprises an exhaustive survey of relevant literature of most relevant articles on Soft Computing techniques applied in neuro-science. This literature survey reveals that many researchers have applied soft computing techniques to neurology problems. This survey would help us to understand the difficulties and limitations of such tools/software in an Indian context (Sharma & Gupta, 2014).

Mirco Josefiok, Oliver Norkus and J¨urgen Sauer have observed that DSS consist of three basic components: a data-management component, a knowledge-base and a user interface. In case of Web-based DSS, they can be probably deployed on individual servers. DSS are very close to database management systems (DBMS) and are often built on top of a DBMS (Sreekantha et. al., 2015).

From all the surveys above we come to the conclusion that there is basically a great need for the decision support system for neurology. The proposed system i.e. ***Symptomatic Decision Support System*** is a system developed mainly to help medical practitioners to detect neurological disorder at an early stage.

This is performed by using simple query and answer session. The system will query for the symptoms and on the basis of algorithm will apply inference procedure on answers of queries the output resulting as a possible disease diagnosis with accuracy. The proposed system is able to diagnose neurological disorders like Epilepsy, Stroke, and Parkinson's disease.

4. Implementation

There are lots of web-based applications which utilize (XAMPP Server, MySQL and PHP). The software stack which is open source is easy to use and also reliable and reasonable in performance, we are using XAMPP Server set up on our server side.

4.1. PHP Module

This is basically used for data linking in this system and it is used for linking sign up/login form. The question form is used for checking the ticking of check box. This same mechanism is used for other two diseases.

4.2. Database Module

In this module the data of the patients is stored for the disease which is selected by them. The analysis is displayed, a case study is performed and three types of graphs are displayed i.e. pie chart, bar chart and the symptoms graph for case study. This mechanism is the same for other two diseases also.

- **Pi-Chart Module**

Pi-Chart is a PHP library that will help to create anti-aliased charts or pictures directly from web server. Pie chart is a circular statistical graphic which is divided into slices to illustrate numeric proportions; it displays the entered patient's data in form of percentage. It also displays the Parkinson and non-Parkinson patients in form of percentage.

- **Bar Chart**

Bar chart is vertical and horizontal presentation of data it shows the number of Parkinson and non-Parkinson patients horizontally.

- **Symptoms Graph**

Symptoms graph i.e. line graph which will show the symptoms of the patients i.e. the mostly ticked symptom in checkbox.

5. Result

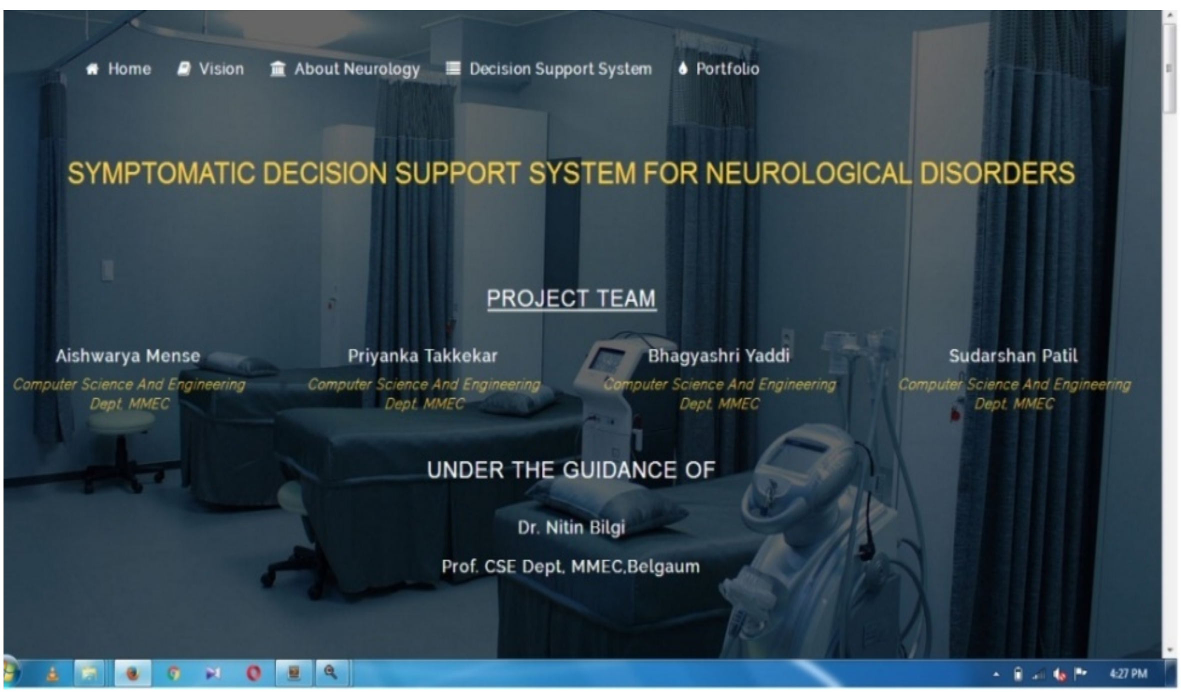

Figure 6. Home page

Figure 7. Decision Support System

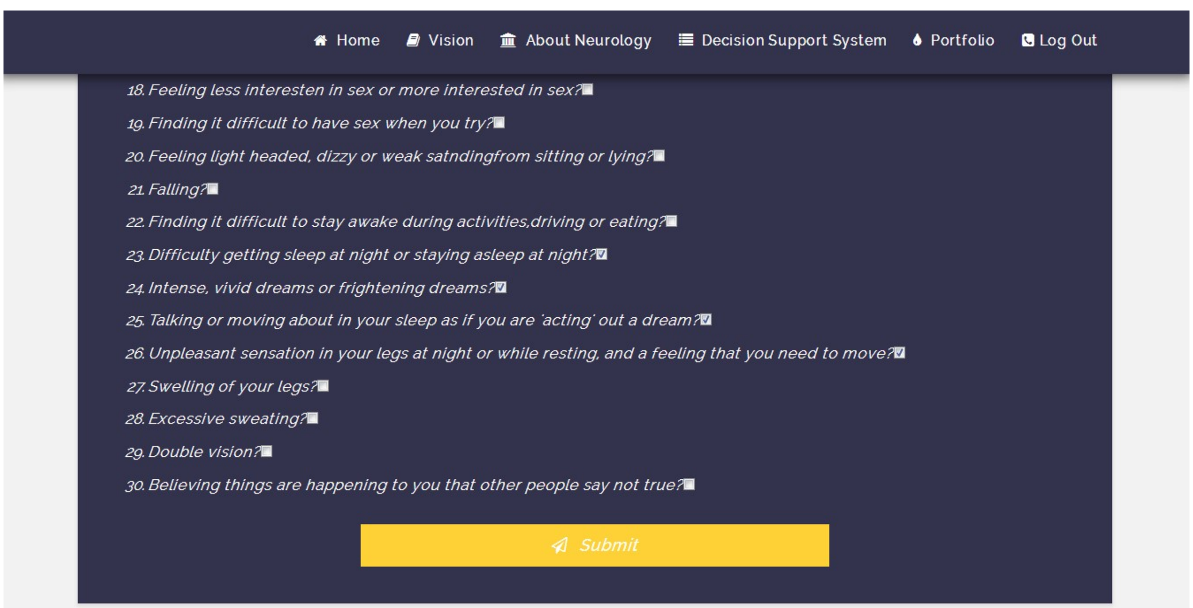

Figure 8. When patient ticks the checkbox

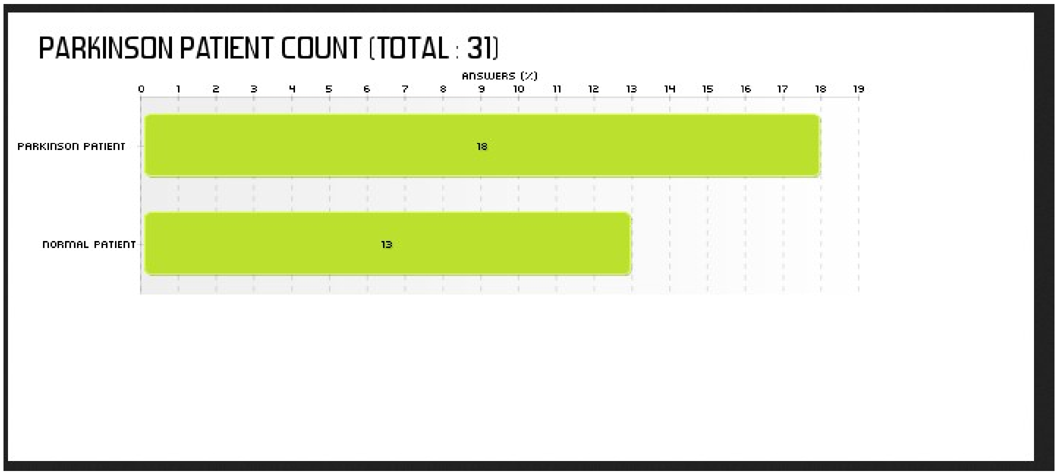

Figure 9. Bar Graph of Parkinson patient's data

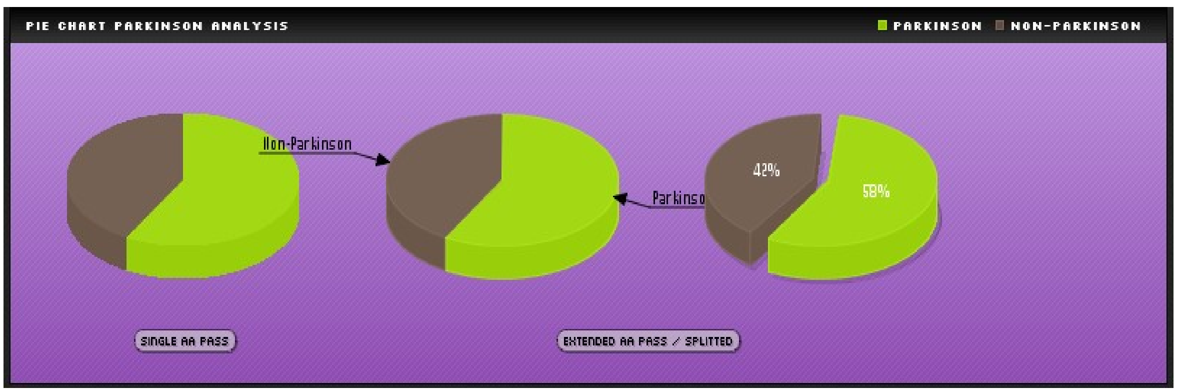

Figure 10. Pie chart of Parkinson patient's data

Figure 11. Parkinson symptoms line graph

6. Conclusion / Future work

In this Paper named "Symptomatic Decision Support System for Neurological Disorders" we have implemented our proposed system and tried to make the Neurology analysis easier for both doctors and patients. This would help doctors to easily put a diagnosis without any paper work. The user can save money and time by using this system.

This research work can be further extended with additions of more neurological diseases and the related symptoms. The system can be further modified and improved as per the doctors and patients' needs.

More tools like chat application can be implemented so that the patient can communicate directly with the doctor, as it will reduce time and will help the patient to know treatment options early.

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